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ABSTRACT

Presented is the student manual for one of a series of self-instructional, computer based learning modules for an introductory, undergraduate chemistry course. Included in this introductory unit on solutions are objectives, prerequisites, pretest, discussion, and 20 problem sets. (BT)

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SOLUTIONS

UNIT 1. INTRODUCTION TO SOLUTIONS, WEIGHT PERCENT, VOLUME PERCENT, PPM

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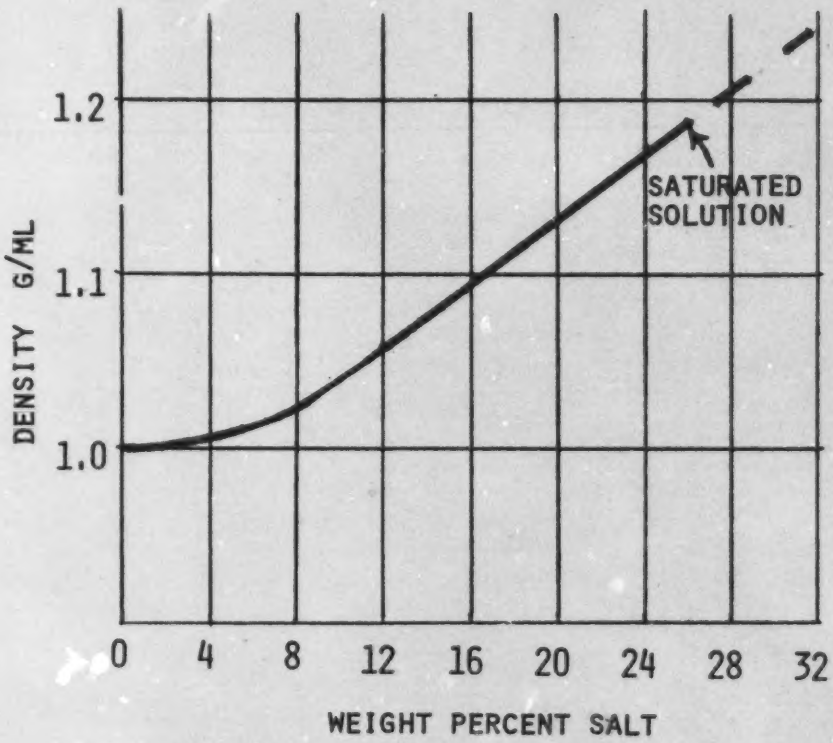
A COMPUTER-ENRICHED MODULE FOR INTRODUCTORY CHEMISTRY



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OBJECTIVES

Upon completion of this module the student will be able to

1. define such terms as solute, solvent, homogeneous, heterogeneous, dilute, level of saturation, concentrated, phase, and component.
2. use concentration units such as weight percent, volume percent, and parts per million (PPM).

PREREQUISITES

The student should have familiarity with

1. formulas, moles.
2. weight and volume units; liters (l), grams (g), milliliters (ml), pounds (lb).
3. be able to convert from one weight or volume unit to another.
4. be able to use density in weight-volume calculations.

PRE-TEST

1. The number of grams in 2.5 lbs is
   (a) 5.507×10^{-3} (b) 2.5 (c) 1135 (d) 5.507×10^{3}
2. The percent of S in aluminum sulfate [$Al_2(SO_4)_3$] is (Atomic Wts.: Al = 27, S = 32, O = 16 g/g-atom)
   (a) 2.8% (b) 28% (c) 0.9% (d) 90%
3. A box is 12 inches long, 24 cm high and 0.15 m wide. Its volume in cubic centimeters (cm^3) is
   (a) 0.0432 (b) 43.2 (c) 1.1×10^{-3} (d) 1.1×10^{4}
4. A block of metal weighs 197 g. When the metal block is dropped into a graduated cylinder the water level rises 23 ml. The density of this metal in g/cm^3 is:
   (a) 0.1167 (b) 23 (c) 8.57 (d) 197
5. One of the following is <u>not</u> a unit of density. That unit is
   (a) lb/in^2 (b) lb/ft^3 (c) g/cm^3 (d) $tons/m^3$
6. Write the formulas of the following compounds
   (a) cadmium acetate
   (b) silver carbonate
   (c) mercuric perchlorate

Answers to pre-test:

1. (c)
2. (b)
3. (d)
4. (c)
5. (a)
6. (a) $Cd(C_2H_3O_2)_2$
   (b) Ag_2CO_3
   (c) $Hg(ClO_4)_2$

INTRODUCTION

Solutions play an important role in a chemist's bag of tricks. They allow him to run chemical reactions in a smooth and controlled manner. Sometimes they allow him to add very small amounts of chemical reagents with great accuracy. Often the choice of solution will control the speed of chemical reactions, an important factor in chemical syntheses.

What is a solution anyway? Well, a solution is a mixture of 2 or more pure substances dispersed on an atomic or molecular level. That means a mixture of salt (NaCl) and sugar ($C_{12}H_{22}O_{11}$) well blended in the solid state is not a solution, even though they are both pure white crystals and would be very difficult to tell apart.

How can we tell a well mixed solution from a pure substance? Easy -- solutions have no fixed composition, while pure substances (with very few exceptions such as transition metal oxides) always do.

For the sake of simplicity let us discuss binary (bi = two) solutions, that is, solutions composed of just 2 substances which we call the components of the solution. Let's call them A and B. Now A and B can each have any physical state, either a solid, liquid, or gas. While most solutions we are aware of may consist of solids or liquids dissolved in liquids (tea with sugar), other types of solutions do occur. For example, pumice stone is a volcanic rock formed by a gas dissolved in a solid, and a gold ring is usually a solid solution (alloy) of copper in gold.

Here are some terms in common use:

State of Matter . . . . . This generally refers to the physical state either solid, liquid or gas. The word phase is also used in this context.

Solvent . . . . . Refers to the component in largest amount, or sometimes refers to the substance which has the same phase as the solution.

Solute . . . . . Refers to substance(s) in smaller amounts. Often the solute will have a state different from the solution; for example, NaCl (solid) dissolved in water to form a liquid solution would be the solute, and the water would be the solvent.

Solution . . . . . The combined solute(s) (there may be more than one), plus the solvent, the total mixture.

Saturated . . . . . A solution which can hold no more of a given solute at a particular temperature. Most substances increase their solubility with an increase in temperature. (But not all!)

Unsaturated . . . . . A solution which can still dissolve more solute at a given temperature.

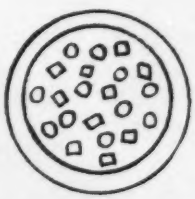
Supersaturated . . . . . A saturated solution which has been cooled so that it contains an excess of solute. Given time the excess solute will generally precipitate out leaving a saturated solution.

Concentration . . . . . This refers to the exact quantitative amounts of each and every component in the solution. There are many different concentration units which can be used to describe a single solution. We are going to devote our time to weight percent, volume percent, and PPM (parts per million).

DISCUSSION

PROPERTIES OF SOLUTIONS

Rather than talk about the properties of solutions in general, let's take as our examples two familiar items, a dish of carrots and peas and a glass of carbonated soda pop. You can pick the flavor.



Carrots and Peas

Popsa Cooler

Figure 1

Let's assume the carrots and peas to be well mixed (not mashed) and made of "pure" carrots and "pure" peas. What is soda pop made of? Here goes: water for the most part, carbon dioxide (CO_2) gas, citric acid (for tartness), sugar (for sweetness), fruit oil (natural or synthetic) for flavor, an edible dye, and some sodium benzoate as a preservative (kills all kinds of bacteria which love sweet stuff). Now that you know what things are made of, let's ask some questions. In these questions we are going to call the carrots and peas mixture "A" and the soda pop mixture "B", OK?

Problems

1. Which of the mixtures is a solution, A or B? Why?
2. Identify each mixture as to whether it is homogeneous or heterogeneous and explain.
3. Which of these is a binary mixture?
4. For each mixture identify the solute(s) and solvent.
5. Answer questions 1-4 for the following mixtures:
   (a) sea water (without the fish)
   (b) blood
   (c) milk
   (d) concrete
   (e) glass

"TRUE" SOLUTIONS

By now you have discovered that the soda pop is a "true" solution and not just an everyday common kind of mixture. Here is how we test for a "true" solution.

Test 1. In true solutions the particles are dispersed in an atomic or molecular state.

Test 2. True solutions never settle out. The oceans have been salty for millions of years and are still getting saltier.

Test 3. A true solution will not scatter light. Think of the dust particles in a darkened movie theater as they dance in the light of the projector beam. This is known as the Tyndall Effect. In order for this to happen a particle must be roughly the same size as a wavelength of visible light.

Problem 6. Compare the size of a chloride ion (Cl^-) (you can find it in some periodic tables of elements) with the wavelength of blue light, about 4000 Å. (1 Å = 10^{-8} cm). Will a Cl^- ion scatter blue light?

Problem 7. After reading Question 6 carefully try to construct a hypothesis as to why milk is white.

SOME IMPORTANT CONCENTRATION UNITS

Chemists generally deal with aqueous (water) solutions containing large varieties of solutes. Now the word concentration refers in a very loose way to the ratio or relative amounts of solute and solvent. We could express these amounts in grams, liters, moles, or whatever unit is most applicable to a given problem. Knowing any one concentration unit for a particular solution it will always be possible to convert it to any other concentration unit, although sometimes we'll need to know densities to do this. In this unit we are going to study the following concentration units:

(a) weight percent (% w/w)
(b) volume percent (% v/v)
(c) parts per million (PPM)

HOW TO CALCULATE THE WEIGHT PERCENT CONCENTRATION

Weight percent is easy to remember because

1. We are going to deal only with weights of solute and solvent and not their volumes or other properties, and
2. Concentration will be expressed as a percentage.

Percentage means parts per hundred. Keep in mind that you do not have to have 100 of anything. For example, if a farmer has 50 sheep and 2 are black and the other 48 white, what percent of his sheep are black?

$$\% \text{ Black} = \frac{\text{No. of Black (2)}}{\text{No. of Black (2)} + \text{No. of White (48)}} \times 100$$

$$= 4\%$$

Notice that the denominator always contains some total number for the mixture. Suppose now a student in the laboratory performs the following operations:

a. weigh out exactly 2 g of KNO_3
b. weigh out exactly 48 g of H_2O
c. mix KNO_3 and H_2O and stir

What is the weight percent concentration of KNO_3 in the solution? Compare with the sheep problem. Your answer should be 4% w/w. Here's the arithmetic --

$$\% \text{ w/w} = \frac{2 \text{ g } KNO_3}{2 \text{ g } KNO_3 + 48 \text{ g } H_2O} \times 100$$

$$= 4\% \text{ w/w}$$

Do we always have to use grams as a weight unit? No. Percentage is really a dimensionless number which has no units. The recipe for concrete might call for 4 tons of small stones to 12 tons of sand.

Problem 8. What percent of this mixture (concrete) is sand?

In general our formula for weight percent (% w/w) will look like this:

$$\% \text{ w/w of A} = \frac{\text{weight of A}}{\underbrace{\text{weight of A + weight of B}}_{\text{always the total}}} \times 100$$

Now concentration does not tell us how much of the total solution we have. If I have a 4% w/w solution of KNO_3 and that's all you know about it, I might have just one drop of this solution or a bathtub full and they could both be 4% w/w. The next example might make this clearer.

Example 1. Suppose we wish to prepare exactly 75 g total of a 10% w/w solution of calcium chloride ($CaCl_2$), how many grams of $CaCl_2$ and how many grams of water must we take?

First let x = g of $CaCl_2$

then $$10\% \text{ w/w} = \frac{x \text{ g } CaCl_2}{75 \text{ g of total solution}} \times 100$$

and $$x = \frac{10 \times 75}{100} = 7.5 \text{ g of } CaCl_2$$

What is the weight of water?

wt of $CaCl_2$ (7.5 g) + wt of H_2O (? g) = total wt of solution (75 g)

wt of H_2O = 75 g solution - 7.5 g solute ($CaCl_2$) = 67.5 g H_2O

So to summarize

7.5 g $CaCl_2$ + 67.5 g H_2O = 75 g total of a 10% w/w solution.

Here are some problems for you to chew on.

Problem 9. How many grams of oxalic acid ($H_2C_2O_4$) do you need to prepare 350 g of a 6% w/w solution? How much water is required?

Problem 10. After hitting a gold strike your ore assays at 0.001% w/w Au. How many tons (1 ton = 2000 lb) of ore must you process to recover 1 lb of pure

gold? At $200 per ounce of gold what is the maximum cost for processing one ton of ore to break even?

Problem 11. Calculate the weight of water in 60 g of a 5% solution of NaCl.

Problem 12. Calculate the final (% w/w) concentration when 70 g of a 3% w/w $ZnSO_4$ solution is mixed with 150 g of a 6% w/w solution of the same solute.

Problem 13. Many properties change with a change in temperature. Some physical properties do not. Discuss the effect of an increase in temperature on the weight percent concentration.

VOLUME PERCENT (% v/v) CONCENTRATION UNIT

As mentioned before, concentration units are meant to be practical and useful and not just labels that we apply indiscriminately. Suppose we wish to mix two liquids, call them A and B, to form a solution. The easiest way to handle liquids is by volume, usually by means of a graduated cylinder, pipet or buret.

Biologists often prepare microscopic specimens for staining by a prior soak in a 95% by volume alcohol (C_2H_5OH) in water solution. This solution could be prepared by mixing 95 ml of alcohol and 5 ml of water to form 100 ml of solution.*

The arithmetic expression for volume percent has the same form as weight percent:

$$\% \text{ v/v of A} = \frac{\text{vol of A}}{\text{vol of A} + \text{vol of B}} \times 100$$

Problem 14. Since it is often wasteful and expensive to prepare more solution than is needed, calculate the volumes of water and alcohol necessary to prepare 60 ml of a 40% v/v alcohol in water solution.

Problem 15. During the American Civil War, soldiers would often be given "watered" whiskey. Some inventive drinker discovered a test whereby a small pile of gunpowder was moistened with the whiskey and then lit with a match. If the whiskey contained less than 50% v/v alcohol, it would just fizzle and go out, but, if the whiskey contained more than 50% v/v it would go "POOF" and be "fit to drink". This "POOF" became "PROOF" and now is the term applied to twice the % v/v alcohol in spirits. Thus, 50% v/v became 100 PROOF. Now you have enough know-how to evalulate the volume of alcohol in 1 quart (1.057 l) of 120 PROOF sour mash Kentucky Bourbon (also known as "white lightning"). Using the density of alcohol as 0.80 g/ml calculate the weight of alcohol in the booze.

Problem 16. Assuming that volumes of liquids usually increase with an increase in temperature, discuss the effect of temperature on the % v/v concentration of a solution.

*Actually when two mutually miscible (soluble) liquids are mixed there may be a slight change of the total volume as the molecules of the two components interact. We are going to ignore such changes now although this effect will be discussed in physical chemistry courses.

VERY DILUTE SOLUTIONS

Very dilute solutions refer to those which have very small amounts of solute. So, concentrations expressed in parts per hundred (% w/w) would result in very small numbers which do not convey to us the direct information we need. Instead of parts per hundred, we use parts per million. Which would you rather see,

0.0001% w/w or 1 PPM ?

In formulating the PPM expression, the amount of solute is so small (usually) that we can ignore it in the total weight of the solution. Watch:

$$\text{PPM of A} = \frac{\text{wt of solute A}}{\text{wt of solvent B}} \times 10^6$$

Since most solutions involve water as the solvent, and the fact that the density of water is ~1 g/ml, a 1 PPM solution would contain 1 mg of solute in 1 liter of water. This is a useful concept to remember.

Example 2. Lithium chloride (LiCl) has been used in the treatment of some types of mental disorders. How many mg of LiCl (MW = 42.5 g/mol) are required to prepare 1 liter of solution containing 5 PPM Li^+ ion? (At. wt.: Li = 7 g/g-atom)

Method:

1. 1 liter of water = 1000 g (assuming density of water = 1 g/ml)
2. $5 \text{ PPM } Li^+ = \frac{\text{g } Li^+}{1000 \text{ g sol'n}} \times 10^6$
3. Then $\text{g } Li^+ = \frac{5 \times 1000}{10^6} = 5 \times 10^{-3} \text{ g } Li^+$
4. $5 \times 10^{-3} \text{ g } Li^+ \times \frac{1 \text{ mol LiCl}}{7 \text{ g } Li^+} \times \frac{42.5 \text{ g LiCl}}{1 \text{ mol LiCl}}$

Ans. 0.0304 g LiCl = 30.4 mg LiCl.

Environmentalists and ecologists have discovered that very small amounts of substances in the PPM concentration range have an enormous effect on the health of a community. The following two questions reflect on these environmental problems.

Problem 17. The insecticide DDT ($C_{14}H_9Cl_5$) usually builds up in the livers of animals to a concentration of 1-2 PPM. Assume an animal liver of 5 lbs contains 2 PPM of DDT, (1 lb = 454 g), calculate the mg of DDT in the liver.

Problem 18. Most cities now fluoridate their water to prevent tooth decay with either liquid hydrofluoric acid (HF) or with solid disodium silico fluoride (Na_2SiF_6). Assume 8 million gallons of water pass through the treatment plant daily (1 gallon = 4 quarts, 1 quart = 1.057 l). Calculate the daily amount of Na_2SiF_6, in pounds, which must be added to the water to give a level of 1 PPM of fluoride ion (F^-).
(At. wts.: Na = 23, F = 19, Si = 28 g/g-atom)

This completes Unit 1 on solutions. A number of computer generated practice problems are included on the following pages.

Problem Set 1

1. A SOLUTION IS PREPARED BY DISSOLVING 117.90 G OF KBr IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.409 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

2. THE SOLUBILITY OF KNO_3 IS 68.1 G KNO_3 PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF KNO_3 AT THIS TEMPERATURE ?

3. IT IS DESIRED TO PREPARE A SOLUTION OF $Ni(NO_3)_2$ IN 356 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $Ni(NO_3)_2$ IS EQUAL TO 15.20. HOW MANY GRAMS OF $Ni(NO_3)_2$ ARE REQUIRED ?

4. 0.799 MOLES OF $KMnO_4$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.093 G/ML ?

5. CALCULATE THE WEIGHT PERCENT OF KBr IN A SOLUTION CONTAINING 24.299 G OF KBr IN 799 G OF WATER.

Problem Set 2

1. THE DENSITY OF 31.1 PERCENT KIO_3 SOLUTION IS 1.131 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 23 GRAMS OF KIO_3 ?

2. CALCULATE THE WEIGHT PERCENT OF $BaCl_2$ IN A SOLUTION CONTAINING 20.600 G OF $BaCl_2$ IN 1093 G OF WATER.

3. CALCULATE THE WEIGHT PERCENT OF $NaClO_3$ IN A SOLUTION CONTAINING 57 G OF WATER IN 0.73 MOLES OF $NaClO_3$.

4. THE SOLUBILITY OF $KMnO_4$ IS 69.9 G $KMnO_4$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $KMnO_4$ AT THIS TEMPERATURE ?

5. A SOLUTION IS PREPARED BY DISSOLVING 12.15 G OF KNO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.013 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

Problem Set 3

1. IF A SOLUTION OF DENSITY 1.076 G/ML IS PREPARED BY DISSOLVING 1.4 MOLES OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $BaCl_2$ IN THE SOLUTION?

2. CALCULATE THE WEIGHT PERCENT OF $KMnO_4$ IN A SOLUTION CONTAINING 49 G OF WATER IN 0.62 MOLES OF $KMnO_4$.

3. CALCULATE THE WEIGHT PERCENT OF $Ni(NO_3)_2$ IN A SOLUTION CONTAINING 25.500 G OF $Ni(NO_3)_2$ IN 629 G OF WATER.

4. THE SOLUBILITY OF Na_3PO_4 IS 58.8 G Na_3PO_4 PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF Na_3PO_4 AT THIS TEMPERATURE ?

5. 0.640 MOLES OF $(NH_4)_3PO_4$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.352 G/ML ?

Problem Set 4

1. A SOLUTION IS PREPARED BY DISSOLVING 124.20 G OF Na_3PO_4 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.130 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

2. IT IS DESIRED TO PREPARE A SOLUTION OF $MnCl_2$ IN 391 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $MnCl_2$ IS EQUAL TO 3.48. HOW MANY GRAMS OF $MnCl_2$ ARE REQUIRED ?

3. CALCULATE THE WEIGHT PERCENT OF KBr IN A SOLUTION CONTAINING 79 G OF WATER IN 0.31 MOLES OF KBr.

4. 0.616 MOLES OF $Cd(NO_3)_2$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.047 G/ML ?

5. THE SOLUBILITY OF $BaCl_2$ IS 73.2 G $BaCl_2$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $BaCl_2$ AT THIS TEMPERATURE ?

Problem Set 5

1. 0.419 MOLES OF $KMnO_4$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.074 G/ML ?

2. CALCULATE THE WEIGHT PERCENT OF KIO_3 IN A SOLUTION CONTAINING 107 G OF WATER IN 0.25 MOLES OF KIO_3.

3. THE SOLUBILITY OF $NaClO_3$ IS 23.4 G $NaClO_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $NaClO_3$ AT THIS TEMPERATURE ?

4. THE DENSITY OF 90.0 PERCENT $(NH_4)_3PO_4$ SOLUTION IS 1.190 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 76 GRAMS OF $(NH_4)_3PO_4$?

5. CALCULATE THE WEIGHT PERCENT OF $AgNO_3$ IN A SOLUTION CONTAINING 18.249 G OF $AgNO_3$ IN 146 G OF WATER.

Problem Set 6

1. CALCULATE THE WEIGHT PERCENT OF $KMnO_4$ IN A SOLUTION CONTAINING 65 G OF WATER IN 0.60 MOLES OF $KMnO_4$.

2. THE DENSITY OF 74.7 PERCENT $MgSO_4$ SOLUTION IS 1.175 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 13 GRAMS OF $MgSO_4$?

3. A SOLUTION IS PREPARED BY DISSOLVING 16.20 G OF Na_3PO_4 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.017 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

4. IT IS DESIRED TO PREPARE A SOLUTION OF $MnCl_2$ IN 162 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $MnCl_2$ IS EQUAL TO 5.48. HOW MANY GRAMS OF $MnCl_2$ ARE REQUIRED ?

5. THE SOLUBILITY OF $Al_2(SO_4)_3$ IS 89.3 G $Al_2(SO_4)_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $Al_2(SO_4)_3$ AT THIS TEMPERATURE ?

Problem Set 7

1. CALCULATE THE WEIGHT PERCENT OF Na_2CO_3 IN A SOLUTION CONTAINING 46.749 G OF Na_2CO_3 IN 953 G OF WATER.

2. THE DENSITY OF 95.9 PERCENT $KMnO_4$ SOLUTION IS 1.196 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 74 GRAMS OF $KMnO_4$?

3. 0.258 MOLES OF $K_2Cr_2O_7$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.371 G/ML ?

4. CALCULATE THE WEIGHT PERCENT OF KBr IN A SOLUTION CONTAINING 76 G OF WATER IN 1.03 MOLES OF KBr.

5. A SOLUTION IS PREPARED BY DISSOLVING 86.10 G OF $NaClO_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.491 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

Problem Set 8

1. THE SOLUBILITY OF KBr IS 14.6 G KBr PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF KBr AT THIS TEMPERATURE ?

2. CALCULATE THE WEIGHT PERCENT OF KNO_3 IN A SOLUTION CONTAINING 28.049 G OF KNO_3 IN 252 G OF WATER.

3. THE DENSITY OF 79.5 PERCENT Na_2CO_3 SOLUTION IS 1.179 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 84 GRAMS OF Na_2CO_3 ?

4. 0.565 MOLES OF $AgNO_3$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.162 G/ML ?

5. IF A SOLUTION OF DENSITY 1.338 G/ML IS PREPARED BY DISSOLVING 1.2 MOLES OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $Cd(NO_3)_2$ IN THE SOLUTION?

Problem Set 9

1. THE DENSITY OF 51.5 PERCENT Na_2CO_3 SOLUTION IS 1.151 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 28 GRAMS OF Na_2CO_3 ?

2. 0.474 MOLES OF $NaClO_3$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.049 G/ML ?

3. CALCULATE THE WEIGHT PERCENT OF $MgSO_4$ IN A SOLUTION CONTAINING 104 G OF WATER IN 0.51 MOLES OF $MgSO_4$.

4. IT IS DESIRED TO PREPARE A SOLUTION OF $CrCl_3$ IN 278 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $CrCl_3$ IS EQUAL TO 9.58. HOW MANY GRAMS OF $CrCl_3$ ARE REQUIRED ?

5. A SOLUTION IS PREPARED BY DISSOLVING 125.70 G OF $K_2Cr_2O_7$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.181 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

Problem Set 10

1. IF A SOLUTION OF DENSITY 1.464 G/ML IS PREPARED BY DISSOLVING 2.8 MOLES OF $CrCl_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $CrCl_3$ IN THE SOLUTION?

2. THE DENSITY OF 99.8 PERCENT $K_2Cr_2C_7$ SOLUTION IS 1.200 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 10 GRAMS OF $K_2Cr_2C_7$?

3. CALCULATE THE WEIGHT PERCENT OF KBr IN A SOLUTION CONTAINING 35.299 G OF KBr IN 614 G OF WATER.

4. THE SOLUBILITY OF $NaClO_3$ IS 17.4 G $NaClO_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $NaClO_3$ AT THIS TEMPERATURE ?

5. CALCULATE THE WEIGHT PERCENT OF KIO_3 IN A SOLUTION CONTAINING 39 G OF WATER IN 0.93 MOLES OF KIO_3.

Problem Set 11

1. THE DENSITY OF 32.6 PERCENT KBr SOLUTION IS 1.133 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 52 GRAMS OF KBr ?

2. THE SOLUBILITY OF $CaBr_2$ IS 12.3 G $CaBr_2$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $CaBr_2$ AT THIS TEMPERATURE ?

3. A SOLUTION IS PREPARED BY DISSOLVING 103.95 G OF $Al_2(SO_4)_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.164 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

4. IT IS DESIRED TO PREPARE A SOLUTION OF KIO_3 IN 465 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF KIO_3 IS EQUAL TO 8.02. HOW MANY GRAMS OF KIO_3 ARE REQUIRED ?

5. 0.320 MOLES OF $(NH_4)_3PO_4$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.041 G/ML ?

Problem Set 12

1. IF A SOLUTION OF DENSITY 1.316 G/ML IS PREPARED BY DISSOLVING 2.3 MOLES OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $BaCl_2$ IN THE SOLUTION?

2. CALCULATE THE WEIGHT PERCENT OF KNO_3 IN A SOLUTION CONTAINING 22 G OF WATER IN 0.38 MOLES OF KNO_3.

3. A SOLUTION IS PREPARED BY DISSOLVING 29.70 G OF $K_2Cr_2O_7$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.211 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

4. CALCULATE THE WEIGHT PERCENT OF $BaCl_2$ IN A SOLUTION CONTAINING 12.600 G OF $BaCl_2$ IN 921 G OF WATER.

5. 0.823 MOLES OF $CaBr_2$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.451 G/ML ?

Problem Set 13

1. THE DENSITY OF 96.5 PERCENT $AgNO_3$ SOLUTION IS 1.196 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 93 GRAMS OF $AgNO_3$?

2. A SOLUTION IS PREPARED BY DISSOLVING 70.50 G OF $Ni(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.114 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

3. THE SOLUBILITY OF Na_3PO_4 IS 76.8 G Na_3PO_4 PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF Na_3PO_4 AT THIS TEMPERATURE ?

4. CALCULATE THE WEIGHT PERCENT OF $FeCl_3$ IN A SOLUTION CONTAINING 16.849 G OF $FeCl_3$ IN 1012 G OF WATER.

5. CALCULATE THE WEIGHT PERCENT OF $Cd(NO_3)_2$ IN A SOLUTION CONTAINING 47 G OF WATER IN 0.28 MOLES OF $Cd(NO_3)_2$.

Problem Set 14

1. CALCULATE THE WEIGHT PERCENT OF $Ni(NO_3)_2$ IN A SOLUTION CONTAINING 46.499 G OF $Ni(NO_3)_2$ IN 886 G OF WATER.

2. THE DENSITY OF 81.7 PERCENT $FeCl_3$ SOLUTION IS 1.182 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 87 GRAMS OF $FeCl_3$?

3. IF A SOLUTION OF DENSITY 1.435 G/ML IS PREPARED BY DISSOLVING 1.5 MOLES OF KIO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF KIO_3 IN THE SOLUTION?

4. 0.113 MOLES OF $Al_2(SO_4)_3$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.104 G/ML ?

5. IT IS DESIRED TO PREPARE A SOLUTION OF $K_2Cr_2O_7$ IN 128 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $K_2Cr_2O_7$ IS EQUAL TO 7.36. HOW MANY GRAMS OF $K_2Cr_2O_7$ ARE REQUIRED ?

Problem Set 15

1. THE DENSITY OF 10.3 PERCENT $CaBr_2$ SOLUTION IS 1.110 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 91 GRAMS OF $CaBr_2$?

2. A SOLUTION IS PREPARED BY DISSOLVING 41.25 G OF Na_2CO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.489 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

3. IT IS DESIRED TO PREPARE A SOLUTION OF $CrCl_3$ IN 450 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $CrCl_3$ IS EQUAL TO 15.58. HOW MANY GRAMS OF $CrCl_3$ ARE REQUIRED ?

4. CALCULATE THE WEIGHT PERCENT OF $MnCl_2$ IN A SOLUTION CONTAINING 5.199 G OF $MnCl_2$ IN 832 G OF WATER.

5. IF A SOLUTION OF DENSITY 1.146 G/ML IS PREPARED BY DISSOLVING 0.3 MOLES OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $BaCl_2$ IN THE SOLUTION?

Problem Set 16

1. CALCULATE THE WEIGHT PERCENT OF $MnCl_2$ IN A SOLUTION CONTAINING 49 G OF WATER IN 0.18 MOLES OF $MnCl_2$.

2. IF A SOLUTION OF DENSITY 1.494 G/ML IS PREPARED BY DISSOLVING 0.8 MOLES OF Na_3PO_4 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF Na_3PO_4 IN THE SOLUTION?

3. 0.944 MOLES OF $MnCl_2$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.208 G/ML ?

4. THE DENSITY OF 39.4 PERCENT $NaClO_3$ SOLUTION IS 1.139 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 76 GRAMS OF $NaClO_3$?

5. CALCULATE THE WEIGHT PERCENT OF $KMnO_4$ IN A SOLUTION CONTAINING 14.950 G OF $KMnO_4$ IN 836 G OF WATER.

Problem Set 17

1. THE SOLUBILITY OF $K_2Cr_2O_7$ IS 89.8 G $K_2Cr_2O_7$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $K_2Cr_2O_7$ AT THIS TEMPERATURE ?

2. THE DENSITY OF 21.0 PERCENT $Ni(NO_3)_2$ SOLUTION IS 1.121 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 78 GRAMS OF $Ni(NO_3)_2$?

3. CALCULATE THE WEIGHT PERCENT OF $FeCl_3$ IN A SOLUTION CONTAINING 23.849 G OF $FeCl_3$ IN 490 G OF WATER.

4. CALCULATE THE WEIGHT PERCENT OF $KMnO_4$ IN A SOLUTION CONTAINING 66 G OF WATER IN 0.68 MOLES OF $KMnO_4$.

5. IF A SOLUTION OF DENSITY 1.320 G/ML IS PREPARED BY DISSOLVING 0.7 MOLES OF $(NH_4)_3PO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $(NH_4)_3PO_4$ IN THE SOLUTION?

Problem Set 18

1. THE SOLUBILITY OF $Al_2(SO_4)_3$ IS 79.3 G $Al_2(SO_4)_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $Al_2(SO_4)_3$ AT THIS TEMPERATURE ?

2. CALCULATE THE WEIGHT PERCENT OF $KMnO_4$ IN A SOLUTION CONTAINING 50 G OF WATER IN 0.90 MOLES OF $KMnO_4$.

3. THE DENSITY OF 16.6 PERCENT KBr SOLUTION IS 1.117 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 86 GRAMS OF KBr ?

4. A SOLUTION IS PREPARED BY DISSOLVING 33.60 G OF $MnCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.311 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

5. IF A SOLUTION OF DENSITY 1.326 G/ML IS PREPARED BY DISSOLVING 1.8 MOLES OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $BaCl_2$ IN THE SOLUTION?

Problem Set 19

1. IT IS DESIRED TO PREPARE A SOLUTION OF $K_2Cr_2O_7$ IN 209 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $K_2Cr_2O_7$ IS EQUAL TO 20.16. HOW MANY GRAMS OF $K_2Cr_2O_7$ ARE REQUIRED ?

2. CALCULATE THE WEIGHT PERCENT OF $CrCl_3$ IN A SOLUTION CONTAINING 70 G OF WATER IN 0.27 MOLES OF $CrCl_3$.

3. CALCULATE THE WEIGHT PERCENT OF $Al_2(SO_4)_3$ IN A SOLUTION CONTAINING 43.650 G OF $Al_2(SO_4)_3$ IN 745 G OF WATER.

4. A SOLUTION IS PREPARED BY DISSOLVING 127.80 G OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.312 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

5. 0.721 MOLES OF KNO_3 IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.430 G/ML ?

Problem Set 20

1. THE SOLUBILITY OF Na_2CO_3 IS 11.5 G Na_2CO_3 PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF Na_2CO_3 AT THIS TEMPERATURE ?

2. 0.423 MOLES OF $CaBr_2$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.307 G/ML ?

3. IT IS DESIRED TO PREPARE A SOLUTION OF $CrCl_3$ IN 207 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $CrCl_3$ IS EQUAL TO 3.18. HOW MANY GRAMS OF $CrCl_3$ ARE REQUIRED ?

4. A SOLUTION IS PREPARED BY DISSOLVING 74.40 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.200 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

5. IF A SOLUTION OF DENSITY 1.148 G/ML IS PREPARED BY DISSOLVING 1.6 MOLES OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $Cd(NO_3)_2$ IN THE SOLUTION?

The CM Project

The Computer-enriched Module (CM) project is a collaborative effort by 19 faculty members in the disciplines of chemistry, mathematics and physics, to produce self-instructional computer-based materials at the introductory college level in those disciplines. Each module is designed to be usable in an academic environment with minimal computational facilities, and by students and faculty who are not programming experts. It may be used as an adjunct to standard textual materials, or in many cases, as a replacement for them. The primary aim of each module is to use the computer in such a way that students may take a more active role in the development and discovery of concepts and phenomena.

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